DOCUMENT RESUME

ED 297 943 SE 049 414

AUTHOR Hofmeister, Alan M.; And Others
TITLE Developing and Validating Science Education Videodiscs.
PUB DATE 88
NOTE 39p.
PUB TYPE Repor.s - Descriptive (141)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Educational Development; *Formative Evaluation; Interactive Video; *Material Development; Optical Disks; *Program Development; Program Evaluation; Science Education; Secondary Education; *Secondary School Science; Teaching Methods; *Technological Advancement; *Videodisks; Video Equipment

ABSTRACT

The development of videodiscs for science instruction in public schools requires a recognition of the unique characteristics of the public school environment and sensitivity to the persistent problems associated with science content instruction. This report discusses the conceptualization, development, and formative evaluation of a series of science education videodiscs. Three major concerns addressed by the development of the "Core Concepts" videodisc program included: (1) a concern for the instructional setting; (2) an emphasis on courseware rather than hardware; and (3) a willingness to make the necessary "front-end" investment. The discs were designed to enhance the efforts of teachers working in both individual and group instructional settings. In presenting the content, particular attention was given to problems associated with the use of terminology and fragmentation of information. The formative data indicated that videodisc programs can enhance the effectiveness of teachers and substantively impact the student achievement and attitudes. (Author/CW)

Developing and Validating
Science Education Videodiscs

Alan M. Hofmeister
Utah State University
Logan, UT 84322-6800

Siegfried Engelmann
University of Oregon
Eugene, OR 97401

Douglas Carnine
University of Oregon
Eugene, OR 97401

Running head: DEVELOPING AND VALIDATING SCIENCE EDUCATION VIDEODISCS

Abstract

The development of videodiscs for science instruction in public schools requires a recognition of the unique characteristics of the public school environment and a sensitivity to the persistent problems associated with science content instruction. This report discusses the conceptualization, development, and formative evaluation of a series of science education videodiscs. The discs were designed to enhance the efforts of teachers working in both individual and group instructional settings. In presenting the content, particular attention was given to problems associated with the use of terminology and the fragmentation of information. The formative data indicates that videodisc programs can enhance the effectiveness of teachers and substantively impact the student achievement and attitudes.

Developing and Validating Science Education Videodiscs

The development of a quality instructional program in science education requires a sensitivity to issues that constantly increase instructional problems for science teachers. An understanding of these issues can be gained by focusing on the process of course development rather than analyzing data from the use of a finished product. At a time when the research literature almost exclusively confined program and product research reporting to comparative evaluations of finished products, Cronbach (1963) made the following observation:

> Evaluation used to improve the course while it is still fluid contributes more to the improvement of education than evaluation used to appraise a product already on the market. (p. 675).

Scriven (1967) used the terms "formative" and "summative" to discriminate between the two approaches to instructional program evaluation implied in Cronbach's observation on the relative value of different evaluation activities.

In the formative stage, investments in "polishing" the product are minimal. Field testing is restricted to the intense observation of small samples of the target population to determine reasons for product malfunction. Consultant critiques and other similar evaluation practices occur as early as possible, before there is a major fiscal and ego investment in the preliminary product characteristics and content. Only when

the formative stage is largely completed are major investments made in the appearance and "packaging" of the product. Subsequent summative field testing usually includes much larger samples of the target population, and the associated evaluation procedures are concerned with assessment of the final outcomes rather than studying product functioning through the more intensive and intrusive monitoring practices of formative evaluation. Generalization and experimental control are far more important concerns in summative evaluations than in formative evaluations.

The development and validation of a series of videodisc-based programs entitled "Core Concepts in Math and Science" was initiated in 1982 as a major cooperative effort among private industry, faculty at several universities, and administrators and teachers from a range of school districts from coast to coast. This report addresses the development and formative evaluation of the science education programs, and the program "Understanding Chemistry and Energy," in particular. Reports on the formative and summative evaluation of the math programs have already been published (Hofmeister, Engelmann, & Carnine, 1985; Carnine, Engelmann, Hofmeister, Kelly, 1987; Hofmeister, 1987); Hasselbring, Sherwood, & Bransford, 1986).

<u>Hardware, Courseware and Instructional Settings</u>

Levin and Meister, in their in-depth review of the contribution and promise of instructional technology, made the following observations:

> In practice, no educational technology, including CAI, has come close to fulfilling its promise on a systematic or sustained basis. (p. 2)
>
> It is the thesis of this paper that the generic failure of educational technologies has been due largely to a misplaced obsession with the hardware and neglect of the software, other resources, and instructional settings that are necessary to successful implementation. (p. 9)

Levin and Meister observed that good software is "technically feasible," as evidenced in the success of the Sesame Street and NOVA series, and several Plato CAI programs. They further observed that the development of quality software requires a large organizational and financial effort, spread over several years.

In keeping with the above-listed observations and recommendations by Levin and Meister, the development and validation of the "Core Concepts" videodisc program has been characterized by:

1. <u>A concern for the instructional setting</u>. The reality in public schools is that most effective science teachers use a

combination of individual, small-group and large-group settings (Tobin, 1986). The videodisc programs were designed and validated for use in both individual and group settings.

2. An emphasis on courseware rather than hardware. The project staff selected the consumer laser videodisc player, a modestly priced, robust, and flexible device. The programs were designed and validated so that one hardware system could be shared by four or five teachers. Designing systems so that they could be implemented on the basis of one per building, rather than one per student or one per classroom, dramatically changed the cost and role of the hardware. The majority of the program development resources were invested in the courseware needed to effectively instruct in both individual and group settings.

3. A willingness to make the necessary "front end" investment. Typically, a three-disc, 35-lesson course has required three to four years to complete, and entailed at least three field-test and revision cycles. It was not unusual for some parts of a course to be revised seven or eight times as a result of consultant input and the formative field-test data. After the field-test versions had consistently facilitated student mastery, a large investment was then made in the final version to achieve a "broadcast quality" product with dynamic pacing, professional narration, and powerful three dimensional graphics to exemplify and simulate the different principles and phenomena. The priorities of the project staff were clear:

curricular and instructional integrity were achieved with the somewhat crude prototypes before any major investment in the final "polishing" of the video and print materials.

The Courseware

The "courseware" used in the final version of each of the Core Concepts products consisted of videodiscs, student workbooks, and a teacher's manual. When the products are used for group instruction, the videodisc player and television are placed at the front of the classroom and replace most of the teacher's chalkboard and other media presentations. The teacher spends virtually all the instructional time on the classroom floor monitoring and interacting with students, while managing the videodisc player by the hand-held remote control.

In a typical instructional interaction, the teacher would signal the videodisc player to initiate a demonstration. The player would present the demonstration, pose a problem to check on student understanding, and stop automatically, with the problem summarized on the screen. When the teacher felt the students were ready for feedback, a button press on the remote control would present the answer and often the reason for the answer. A wide range of branching options allowed the teacher to access additional examples or bypass material, based on assessments of student mastery. The use of individual student workbooks facilitated student interaction and the coordination of independent practice.

costs are all added to teacher costs. In some approaches to education outside the public schools, the technology-based, individual learning station is often viewed as a teacher replacement and the cost relationship between instructor and technology can be varied. The Core Concepts project staff accepted the central role of the classroom teacher in public school education and stressed teacher enhancement rather than teacher replacement. The ability to use videodisc programs in group settings reduced costs and increased the effectiveness of existing instructional practices.

Rogers (1987), in discussing the role of television in science instruction, stated,

> There is a common denominator among successful experiences in using television as a teaching tool. It is a conscious effort to preserve the relationship between instructor and student. (p. 461)

The design of the Core Concepts programs did more than preserve the relationship between instructor and student. This relationship was clearly enhanced by freeing teachers from the chalkboard and having them spend the majority of the time on the classroom floor. Comments from teachers have consistently reported an increase in individual contacts with students, a greater awareness of student performance, and a reduction in class management problems.

costs are all added to teacher costs. In some approaches to education outside the public schools, the technology-based, individual learning station is often viewed as a teacher replacement and the cost relationship between instructor and technology can be varied. The Core Concepts project staff accepted the central role of the classroom teacher in public school education and stressed teacher enhancement rather than teacher replacement. The ability to use videodisc programs in group settings reduced costs and increased the effectiveness of existing instructional practices.

Rogers (1987), in discussing the role of television in science instruction, stated,

> There is a common denominator among successful experiences in using television as a teaching tool. It is a conscious effort to preserve the relationship between instructor and student. (p. 461)

The design of the Core Concepts programs did more than preserve the relationship between instructor and student. This relationship was clearly enhanced by freeing teachers from the chalkboard and having them spend the majority of the time on the classroom floor. Comments from teachers have consistently reported an increase in individual contacts with students, a greater awareness of student performance, and a reduction in class management problems.

Instructional Methodology and Program Validity

The data documenting the attitudinal and achievement outcomes of students is clearly the major source for assessing the validity of a specific instructional program. The probability of achieving appropriate student outcomes will be increased if the selected instructional methodology has already been shown to be effective with similar students and curricular content. Fortunately, the last 15 years of educational research have provided both specific and practical directions. One body of research has become known as the "effectiveness" literature, because it has documented variables that are consistently associated with the more effective teachers. In commenting on this research literature, Duckett (1986) made the observation, "The research on teaching promises--for the first time--a substantive empirical base from which to improve instruction" (p. 162).

The lesson formats used in Core Concepts videodisc programs are consistent with the synthesis from the "effectiveness" research literature, prepared by Rosenshine and Stevens (1986), and summarized as follows:

> In general, researchers have found that when effective teachers teach well structured subjects, they
>
> * Begin a lesson with a short review of previous, prerequisite learning.
> * Begin a lesson with a short statement of goals.

> * Present new material in small steps, with student practice after each step.
> * Give clear and detailed instructions and explanations.
> * Provide a high level of active practice for all students.
> * Ask a large number of questions, check for student understanding, and obtain responses from all students.
> * Guide students during initial practice.
> * Provide systematic feedback and corrections.
> * Provide explicit instruction and practice for seatwork exercises and, where necessary, monitor students during seatwork.
>
> The major components in systematic teaching include teaching in small steps with student practice after each step, guiding students during initial practice, and providing all students with a high level of successful practice. Of course, all teachers use some of these behaviors some of the time, but the most effective teachers use most of them almost all the time. (p. 377)

Because the "effectiveness" literature has been derived from both the correlational and controlled experimental manipulation of practices used consistently by effective teachers, the findings provide a frame of reference that increases both the potent[illegible]alidity and the level of compatibility with public scho[illegible]rces and practices. This dependence on the

"effectiveness" research literature represents a conservative approach to a technological-based product and reduces the risk of subjecting the teacher to "future shock" or developing expensive and faddish products characterized by "innovation" rather than substance.

Technology and Instructional Power

While the project staff were appreciative of the ability of videodisc technology to allow the teacher to access a wide range of motion sequences and "still frames" based on student needs, the primary value of the technology was its role as a very flexible vehicle for the characteristics of effective instruction. The quality of the curricular and instructional "knowledge base" represented in the courseware, rather than the attributes of the technology, were considered the major source of instructional power. This approach is consistent with Clark's (1983) review of the research on learning from media. After reviewing studies that examined the learning benefits being assigned to a range of audio, video, and computer-based technologies, Clark stated:

> The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition. Basically, the choice of the vehicle might influence the cost or extent of

distributing instruction, but only the content of the vehicle can influence achievement. (p. 445)

Refinement by Progressive Field Testing

Even with substantive direction from the research and considerable input from a wide range of curriculum consultants, the initial field-test versions of each program required many field tests and revision cycles. One of the most difficult tasks was ensuring that both the goals of "dynamic instructional pacing" and student mastery of the content were achieved. The issue has been summarized as follows:

> . . . a number of researchers have shown that most students, including low-achieving students, learn more when their lessons are conducted at a brisk pace, because a reasonably fast pace serves to stimulate student attentiveness and participation and because more content gets covered by students. This assumes, of course, that the lesson is at a level of difficulty that permits a high rate of student success; material that is too difficult or presented poorly cannot be learned at any instructional pace. (Wyne, Stuck, White, & Coop, 1986, p. 20)

Varying prerequisite skills, instructional sequences, the size of steps, the amount of practice and review, and the amount and range of concept exemplification all helped to ensure brisk, interesting pacing and high levels of student success. Modifications to the prompting on the videodisc screen and

revisions of the supporting print materials helped smooth transitions between instructional activities and allowed teachers to easily adapt instructional presentations and supporting guided and independent practice activities to meet the immediate instructional needs of students.

Product Design and Science Education

Work on the three-disc program, "Understanding Chemistry and Energy," and the four-disc earth science program was preceded by the development and validation of three math programs, a three-disc fractions program, a one-disc decimals program, and a three-disc word problems program. While the word problems program, with its emphasis on teaching specific problem solving strategies, had many similarities with some of the science content, the team encountered many instructional design issues that required a different approach or a different emphasis. In essence, the development team found themselves using all the procedures in the math programs as well as several additional procedures. The following additions were necessary to counter problems identified by curriculum consultants and field-test findings.

Countering Curricular Fragmentation

In summarizing one of the major problems associated with science teaching, Reif (1987) stated, ". . . students exhibit

many mistakes traceable to knowledge that is fragmented and uninterpretable" (p. 309). The tendency to teach science as a collection of isolated, unrelated facts appears to be endemic in both the education of science teachers and students. Wivagg (1987), in discussing the preparation of high school biology teachers, noted:

> College biology textbooks have become increasingly encyclopedic during the past twenty years. . . . new high school biology teachers . . . are overwhelmed by details and overlook the integrity and elegance of biological concepts. (p. 71)

One way of reducing the fragmentation of knowledge is to ensure that individual facts are taught as components of a larger frame of reference and that this larger unit clearly shows the functional and comparative relationships among the individual facts. The larger unit, not the isolated facts, should then be a primary reference point for solving problems and applying knowledge. In reviewing the research literature on cognitive factors affecting chemistry achievement, Chandran, Treagust, and Tobin (1987) noted that increased achievement was associated with a student's ability to organize content into larger "chunks," or schemes. They summarized their observations as follows:

> . . . the greater the number of schemes which a student can readily use to assist in the comprehension of the subject

matter in chemistry, the higher will be the achievement. (p. 147)

One practical translation of the research on organizing content knowledge into larger functional units is the use of graphic overviews. These graphic overviews have been variously described as "structured overviews" (Herber & Sanders, 1969). "Graphic Organizers" (Hawk, 1986) and visual-spatial displays (Engelmann & Carnine, 1982; Darch, Carnine, & Kameenui, in press; Darch & Carnine, 1986). Regardless of the terminology used, these overviews used diagrams and associated terminology listings to identify the general terms, and shows the relationship among the concepts represented by the different terms (Moore & Readance, 1984).

In the Core Concepts program, "Understanding Chemistry and Energy," nine visual-spatial displays were needed to summarize isolated facts into larger functional units. Figure 1 shows one of the visual-spatial displays used in "Understanding Chemistry and Energy."

Insert Figure 1 about here

In a comparative research study involving 390 high school life science students in seven experimental and eight control classrooms, Hawk (1986) found statistically significant differences in favor of the use of graphic organizers. In

discussing the findings from the study, Hawk made the following observations.

> There are a number of reasons why graphic organizers enhance learning. First, the graphic organizers provide an overview of the material to be learned. It says, "This is where we are going and these are the things we need to know to get there." Second, the graphic organizer provides a framework that in turn provides reference points to aid the learner in assimilating the new vocabulary and organizing the main concepts into a logical pattern. Third, the graphic organizers cue students as to what to look for as they read their written materials. The organizers direct students to look for cause and effect, for comparison and contrast, for sequence of events, and a variety of other relationships. Fourth, as a review instrument, the graphic organizer is succinct and informative. Its subsuming structure gives stability to the new information, thus strengthening the learners' retention. Fifth, the graphic aspect of the organizers used in this study provide visual aides for written and/or verbalized information. These graphic elements help construct a framework of vocabulary and concepts for learners. (p. 86)

The visual-spatial displays used in "Understanding Chemistry and Energy" formed unifying frames of reference for both the print and video materials. The zoom, highlighting, and freeze-

frame characteristic of the video medium were extensively used to demonstrate the relationship among individual facts and the "bigger picture" encompassed by each visual-spatial display. The integration of the visual-spatial displays into both the print and video materials, and the use of the displays as prompting devices for a wide range of instructional activities is consistent with research indicating that such displays have limited value as "isolated instructional procedures" (Darch, Carnine, Kameenui, in press).

Instructional Clarity

In summarizing their research on the characteristics of outstanding science teachers, Searles and Kudeki (1987) stated:

> The profile of an outstanding science teacher obtained from this study describes a person who is able to maintain a classroom with a pleasant atmosphere where learning can occur, one who is sure of the subject matter being taught, and presents the material to be learned in a clear and effective manner. (p. 11)

The reference to instructional clarity in Searle and Kudeki's description of the outstanding science teacher is supported by a large body of research on the relationship between instructional clarity and student achievement (Smith, 1987; Rakow & Gee, 1987; Smith & Cotten, 1980; Smith & Bramblett, 1981). During the development of the Core Concepts science programs, the following threats to instructional clarity were addressed: (1)

inconsistent use of terminology, (2) vague presentation practices, and (3) inappropriate instructional sequencing.

Terminology

One of the first procedures associated with the identification of potential core concept lesson content was a detailed analysis and review of all terminology. Curriculum consultants reviewed each term to determine which ones were important, which were optional, which were the preferred terms, and which were increasing or decreasing in importance. The terminology was approached on the basis that no attempt should be made to include all the terms. Rather, there was a conscious effort to include only the most important and to teach these to a high level of conceptual mastery. This approach was designed to counter the previously mentioned "encyclopedic" (Wivagg, 1987) and "inconsiderate" (Armbruster, 1984) approach to terminology used in many textbooks.

Instructional Vagueness

The teacher who mumbles to the chalkboard and makes extensive use of words such as "maybe," "several," "sort of," and "kind of," clearly limits communication and student achievement. When the teacher is supported by a well-validated videodisc, even the inexperienced instructor can ensure that students receive a lesson characterized by clarity and dynamic pacing. In the Core Concepts science programs, the video presentations were built

around the audio track. Some films and videotapes are little more than illustrated lectures. A visual is presented and the narrator discusses it; then another visual is presented and the narrator discusses it. In the Core Concepts programs, a carefully designed, briskly paced, tutorial audio track is recorded. The screen material is then designed to exemplify the wording and terminology used in the audio track. The screen simulations and demonstrations, many in three-dimensional color graphics, are coordinated to the tenth of a second with the audio track. Stressing the coordinating role of a briskly paced, question-packed, tutorial narration supports two major goals: instructional precision and personalized delivery.

The formative field testing and revision cycles were designed to identify lapses in instructional clarity. Because of the intensive interaction between student and program, it is possible to empirically identify most of the ineffective instructional components. Most video-based instructional demonstrations used in the science programs are less than a minute long, and the demonstration is usually followed with a written response by the students. During the field tests of prototype versions of each lesson, the written responses of students were collected at the end of each lesson and analyzed to assess the clarity of each instructional demonstration. Such an analysis can pinpoint instructional weaknesses with considerable precision.

In normal use, the teacher is on the classroom floor managing the videodisc player with the aid of the remote control. This ensures that both the identification of instructional problems and their immediate correction are facilitated. Such monitoring and immediate instructional adjustment also add to the clarity of the teaching.

Instructional Sequencing

The careful coordination between a student's entering knowledge and the new information presented in a lesson is one of the most important cognitive factors associated with student achievement. In summarizing their findings on the role of cognitive factors in chemistry achievement, Chandran, Treagust, and Tobin (1987) stated:

> This result raises the possibility that chemistry achievement levels can be enhanced for all learners by ensuring that essential prerequisite knowledge is known before new information is introduced. (p. 158)

They further noted that the two most important cognitive factors associated with chemistry achievement were formal reasoning ability and prior knowledge, and that "It was difficult to appreciably increase formal reasoning ability within the period of a school year . . ." (p. 157). The prerequisite knowledge of each student can, however, be managed and modified on a lesson-by-lesson basis by the specific instructional

behaviors of the teacher.

The Core Concepts programs placed a major emphasis on the monitoring and management of prerequisite knowledge. In each lesson introducing new content, the prerequisite skills were reviewed and tested, and if necessary, taught before the new material was introduced. To ensure that skills were maintained, one lesson each week was set aside for diagnostic testing and selective remediation, based on the results of these diagnostic measures of student mastery. The "random access" facility of the videodisc made it an excellent vehicle for selectively reviewing those skills diagnosed as deficient.

In summary, when the central terminology and associated concepts are carefully identified and sequenced, when critical prerequisite knowledge is carefully monitored and systematically reviewed, and when new terminology is carefully tied to previously mastered concepts, instructional clarity is enhanced and material is introduced in a comparatively error-free manner.

Development and Formative Evaluation

Procedures: An Overview

The major development and formative evaluation procedures used in the preparation of the Core Concepts program included:

1. An analysis of school district curricular and textbook content. For each course, curricula from school districts in several geographically separated states, and four or five widely used textbooks were used for the initial curriculum analysis.

2. <u>An initial listing of possible core concepts</u>. In selecting core concepts, the intention was not to try and teach everything, but to select the most important foundation concepts, and teach them well.

3. <u>A review of the initial listing by content consultants and the associated revision of the listing</u>. Consultant input at this stage was primarily concerned with the selection of the most important concepts and their approximate instructional sequence.

4. <u>The preparation of "track scripts" and their review by consultants</u>. A track script is a preliminary draft of the videodisc script for a specific curriculum strand. Through the review process, consultants make input on sequence, terminology and instructional presentation issues. Figure 2 shows the seven curriculum strands and their relationship with each of the 20 lessons in "Understanding Chemistry and Energy."

Insert Figure 2 about here

The use of track scripts makes the underlying curriculum structures visible to all and facilitates revision on a modular basis.

5. <u>The development of prototype field-test lessons</u>. Lesson scripts are prepared from the revised track scripts. Videotapes and additional print materials are used to approximate the videodisc presentations in the field testing.

6. <u>The field testing and revision of prototype lessons</u>. The process of field testing and revision is repeated until product effectiveness is consistently demonstrated. To date, courses have been through three to five revision cycles. "Understanding Chemistry and Energy" required three major revisions, based on formative field-test results.

Decisions on the degree of product effectiveness are based on an analysis of individual pupil performance on daily in-class assignments, homework, diagnostic tests of student mastery administered as a part of every fifth lesson, and comprehensive pre- and posttests. The daily worksheet analyses provide information on the effectiveness of the specific instructional procedures used in the daily lessons. The fifth lesson tests and the pre- and posttests provide information on the degree of mastery of the core concepts.

The intensive observation of the field-test classrooms was a central strategy in the product development process. We were concerned with data that would guide the product improvement process. Information on student outcomes must be paired with observational data on specific classroom practices to identify the successful and unsuccessful instructional procedures.

7. <u>The preparation of videodiscs and supporting print materials</u>. After the prototype videotape and print materials have been progressively refined and their effectiveness demonstrated through field tests, final versions of the

videodiscs, instructor's manual, and individual student workbooks are developed.

This two-stage video production process, with its dependence on success with the more primitive prototypes, is a very demanding development process. It does, however, ensure that the final product is "overbuilt" and not heavily dependent on the high-interest video effects added in the final product "polishing." Too much dependence on such high-interest video material could result in novelty effects which disguise and overestimate the true long-term instructional valu of the product.

Field-test Results

The primary purpose of a formative evaluation is the identification of information needed to revise the program. The first two field tests were conducted with the normal range of students. When the product had been through two major revisions, based on field-test results, and through numerou other smaller revisions as a result of consultant input, a final, very demanding field test, was used to confirm previous findings and identify any additional problems. In the final field test, 15 students, with a history of major attitudinal and achievement problems in science, were taught the topics on atomic structure, bonding, equilibrium, energy of activation and catalysts, and organic compounds. A pre- and posttest on these topics was

administered to the field-test group. The posttest was also administered to a comparison group.

The field-test group consisted of five students from the special education learning disability program and 10 students in a remedial program. The remedial students had failed a previous science course and were enrolled in a remedial program in an attempt to meet minimum high school graduation requirements. The comparison group consisted of nine students in an advanced placement chemistry class. The mean Stanford Achievement Test percentile scores on Math and Basic Comprehension were 11 for the learning disability students, and 23 for the remedial students in the field-test group. The mean Stanford Achievement Test percentile score for the advanced placement students was 89. The pre- and posttest results are shown in Table 1.

Insert Table 1 about here

The purposes of the third field test were achieved. The observational and student performance data identified additional ways to improve the program. The results also indicated that the program could make a major instructional impact with students who had failed previous science education instruction. One of the most supportive observations was the fact that the remedial students in the field-test group did at least as well or better

than successful advanced placement students in their second year of chemistry.

Attitudinal Reactions

The development team made e› ·nsive use of structured interviews and questionnaires to asses. the attitudinal reactions of teachers and students. Every student in all three field tests responded to at least one questionnaire. Students consistently indicated that, when compared to previous science instruction, they learned more and enjoyed the instruction more. It was felt that the consistent demonstrations of student success were contributing to the positive attitudinal reactions of the students.

In a review of 66 studies on the relationship among affect, ability, and science achievement, Steinkamp and Maehr (1983) summed up the central question as follows:

> An ongoing argument in educational circles concerns whether one should stress the development of proficiency in the hope that motivation will follow, or stress the development of positive feelings in the hope that this will encourage the development of proficiency. (p. 369)

In concluding their synthesis of the research, Steinkamp and Maehr (1983) stated, ". . . one can interpret the results as suggesting that it is primarily the acquisition of proficiency that leads to positive attitudes" (p. 389)

This conclusion by Steinkamp and Maehr is consistent with the rationale and observations of the Core Concepts development team.

Conclusion

Even though the team was concerned that the videodisc contribute to a briskly paced and interest-packed lesson, and even though the program was designed so that the teacher could spend more time personalizing the instructional process through increased individual contacts and more sensitive and immediate instructional management decisions, the development team felt strongly that these instructional features would have limited impact by themselves. The full potential of the program could be achieved only if students perceived the science content as consisting of a limited number of rational elegant concepts that they could master and apply. Without the consistent demonstrations of conceptual mastery, both attitudinal and achievement outcomes would be impossible.

References

Armbruster, B. B. (1984). The problem of "inconsiderate text." In G. G. Duffy, L. R. Roehler, & J. Mason (Eds.), Comprehension instruction: Perspectives and suggestions (pp. 202-217). New York: Longman.

Carnine, D., Engelmann, S., Hofmeister, A., Kelly, B. (1987). Videodisc instruction in fractions, Focus on Learning Problems in Mathematics, 9(1), 31-52.

Chandran, S., Treagust, D. F., & Tobin, K. (1987). The role of cognitive factors in chemistry achievement. Journal of Research in Science Teaching, 24(2), 145-160.

Clark, R. E., (1983). Reconsidering research on learning from media, Review of Educational Research, 53(4),445-459.

Cronbach, L. J. (1963). Course improvement through evaluation. Teachers College Record, 64, 672-683.

Darch, C., & Carnine, D. (1986). Teaching content area material to disabled students. Exceptional Children, 53(3), 240-246.

Darch, C., Carnine, D., & Kameenui E. (in press). The role of graphic organizers and social structure in content area instruction. Journal of Reading Behavior.

Duckett, W. (1986). Linking research and classroom practice, Phi Delta Kappan, 68(2), 161-164.

Engelmann, S. & Carnine, D. (1982). Theory of instruction: Principles and applications, New York: Irvington Publishing.

Hasselbring, T., Sherwood, B., & Bransford, J. (1986). An evaluation of the Mastering Fractions Level-One Instructional Videodisc Program. Nashville, TN: George Peabody College of Vanderbilt University, The Learning Technology Center.

Hawk, P. P. (1986). Using graphic organizers to increase achievement in middle school life science, Science Education, 70(1), 86-87.

Herber, H. L, & Sanders, P. L. (Eds.). (1969). Research in reading in the content areas: First year report. Rochester, NY: Syracuse University, Reading and Language Arts Center.

Hofmeister, A. M., (1987). Technology and teacher enhancement: A videodisc alternative. Logan, UT: Utah State University, Artificial Intelligence Research & Development Unit.

Hofmeister, A. M., Engelmann, S., Carnine, D. (1985). The development and validation of an instructional videodisc program. Paper presented at the American Educational Research Association Meeting, Chicago, IL.

Levin, H. M., & Meister, G. R. (1985). Educational Technology and Computers: Promises, Promises, Always Promises. Stanford, CA: Stanford University, Institute for Research on Educational Finance and Governance.

Lippke, J. (1987). Earmarks of burgeoning videodisc industry at SALT V. E-ITV, 19(4), 32-35.

Moore, D. W., & Readance, J. E. (1984). A quantitative and qualitative review of graphic organizer research. Journal of Educational Research, 78, 11-17.

Rakow, S. J., & Gee, T. C. (1987). Test science, not reading. The Science Teacher, 54(2), 28-31.

Reif, F. (1987). Instructional design, cognition, and technology: Applications to the teaching of scientific concepts, Journal of Research in Science Teaching, 24(4), 309-324.

Rogers, F. A., (1987). Videotapes as a learning tool in biology. Journal of College Science Teaching, 16(5), 458-461.

Rosenshine, B., & Stevens, R. (1986). Teachirg functions. In M. C. Wittrock (Ed.), AERA Handbook of research on teaching (3rd) Edition (pp. 376-391). New York: MacMillan Publishing Company.

Scriven, M. (1967). The methodology of evaluation. Perspectives of curriculum evaluation (AERA Monograph Series). Chicago, IL: Rand McNally.

Searles, W. E., & Kudeki, N. (1987). A comparison of teacher and principal perception of an outstanding science teacher. Journal of Research in Science Teaching, 24(1), 1-13.

Smith, L. R. (1987). Verbal clarifying behaviors, mathematics students participation attitudes. School Science and Mathematics, 87(1), 40-49.

Smith, L. R., & Bramblett, G. H. (1981). The effect of teacher vagueness terms on student performance in high school biology. Journal of Research in Science Teaching, 18, 353-360.

Smith, L. R. & Cotton, M. L. (1980). Effect of lesson vagueness and discontinuity on student achievement and attitudes. Journal of Educational Psychology, 72, 670-675.

Steinkamp, M. W., & Laehr, M. L. (1983). Affect, ability, and science achievement: A quantitative synthesis of correlational research. Review of Educational Research, 53(3), 369-395.

Tobin, K. (1986). Student task involvement and achievement in process-oriented science activities. Science Education, 70(1), 539-548.

Wivagg, D. (1987). High school biology textbooks and college science teaching, The American Biology Teacher, 49(2), 71.

Wyne, M. D., Stuck, G. B., White, K. P., & Coop, R. H. (1986). Carolina teaching performance assessment system, Chapel Hill, NC: The University of North Carolina, School of Education, Group for the Study of Effective Teaching.

Figure Caption

Figure 1. Example of a visual-spatial display.

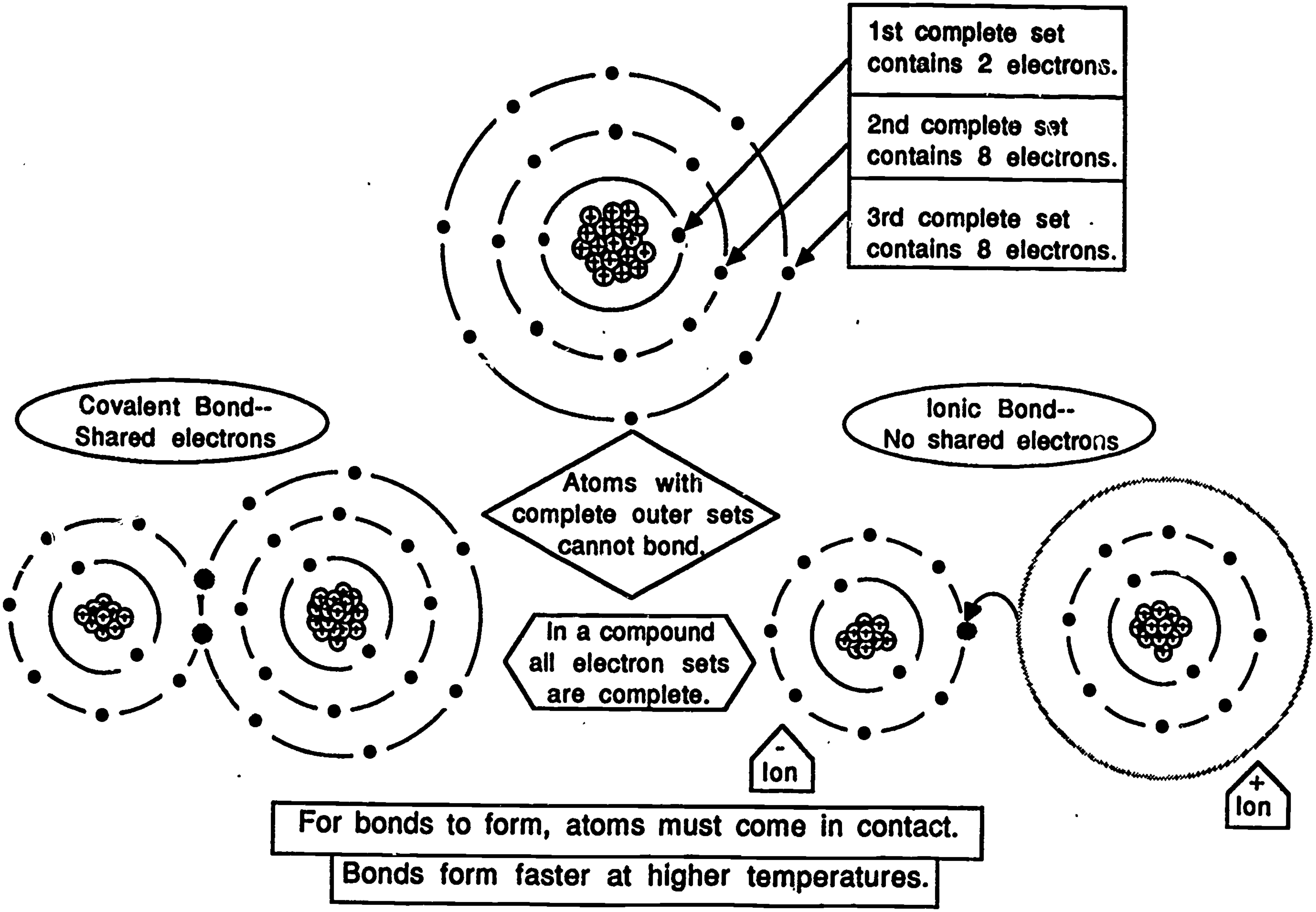
1st complete set contains 2 electrons.
2nd complete set contains 8 electrons.
3rd complete set contains 8 electrons.
Covalent Bond-- Shared electrons
Ionic Bond-- No shared electrons
Atoms with complete outer sets cannot bond.
In a compound all electron sets are complete.
- Ion
+ Ion
For bonds to form, atoms must come in contact.
Bonds form faster at higher temperatures.

Figure Caption

Figure 2. Skill Sequence Chart.

Skill Sequence Chart

	Side 1			Side 2			Side 3				Side 4			Side 5						Side 6
Lesson	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Atomic Structure																				
Protons and Electrons	X			X	T															
Neutrons				X	T															
2. Molecules		X			T															
3. Energy Forms & Conversions		X	X		T															
4. Chemical Energy			X	X	T															
5. Bonding																				
Covalent							X	X	X	T										
Ionic						X	X	X		T										
Hydrogen												X	X		T	X				T
6. Ions								X		T										
7. Organic Compounds									X	T								X	X	
8. Equilibrium											X	X			T					
9. Chemical Reactions											X		X	X	T		X		X	T
10. Energy of Activation & Catalysts														X	T	X				T
11. Water												X	X		T	X				T
12. Diffusion																	X	X		T
13. Chemical Formu'as & Equations																	X			T
CHART Presentation	1	1,2	2	2	1,2	3	3	3	4	3	5	5,6	6	7	4,5	7,6	8	9	9	6,7,8,9
CHART Quizzes			1	2	[illegible]				3	[illegible]	4		5		[illegible]		6	7	8	[illegible]

This Skill Sequence Chart shows the lessons on which the various charts and topics are presented in each of the 20 lessons. For instance, chemical energy is developed in Lessons 3 and 4. Note also that on nearly every lesson, more than one topic is developed. For instance, on Lesson 4, three different topics are developed--atomic structure, neutrons, and chemical energy in reactions.

The bottom two rows show the charts that are used to develop the lesson content and the lessons on which students are quizzed on the wording of the charts that have been introduced (chart quizzes). The course presents four tests, one after every four lessons. All the skills and items tested have been presented earlier in the program.

Table 1

Pretest and Posttest Results for Third Field Test

	Field-test Group				Comparison Group
	Remedial/Learning Disabled				AP Chemistry
Topic	Pretest (N=15)	Posttest (N=15)	Posttest LD(N=5)	Posttest Remedial (N=10)	Posttest (N=9)
Bonding	8%	84%	84%	83%	70%
Equilibrium	23%	67%	67%	67%	26%
Energy of Activation/Catalysts	--	76%	56%	86%	82%
Atomic Structure	36%	73%	48%	86%	93%
Organic Compounds	3%	77%	60%	86%	83%
Averages	17%	75%	63%	82%	71%